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Farming of Carrageenophytes in the Philippines

A SUCCESS STORY OF RED SEAWEEDS CULTIVATION

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FOREWORD

The Asia-Pacific Association of Agricultural Research Institutions (APAARI) is a relatively young and dynamic forum which has over a decade of its establishment, facilitated and strengthened diverse activities on agricultural research and development (ARD). This has been achieved through collaboration and coordination of national, regional and international partnerships; in particular among member NARS and the IARCs.

Information dissemination has been one of the priority activities of APAARI and due focus has been given to bring forth successful case studies of inter-institutional/regional collaboration. In this context, APAARI has so far published 16 success stories based on NARS experiences and expertise, and cost effective technologies have been developed for adoption among NARS. Of these, two success stories relate to coastal ecosystem, namely Tilapia Farming in the Philippines and Bivalve Mariculture in India. Both these studies have provided focus on development of production techniques/methods and farming practices to be adopted locally by the coastal communities.

This success story lays emphasis on carrageenophytes (marine plants commonly known as red seaweeds) that contain carrageenan. Carrageenan constitutes the third most important hydrocolloid in the world after starch and gelatin, and is used for the manufacture of many foods, pharmaceutical and industrial products. The Philippines is the worlds largest producer of carrageenophytes and has established a successful and sustainable industry with involvement of public and private enterprise, providing benefits in particular to the coastal farmers.

I am sure that considering the potential of carrageenophytes farming in other coastal areas in Asia-Pacific region, the information synthesized in this publication will be found useful by interested member NARS.

New Delhi
4 April 2001

(R.S. PARODA)
Executive Secretary
APAARI

INTRODUCTION

Carrageenophytes are marine plants commonly known as red seaweeds (*Rhodophyceae*) that contain carrageenan, a polysaccharide used as a hydrocolloid for the manufacture of many food, pharmaceutical and industrial products.

Carrageenan constitutes the third most important hydrocolloid in the world after starch and gelatin. The world market for carrageenan was valued at $305 million in 1998. Besides carrageenan, the other hydrocolloids extracted from seaweeds are agar and alginates from agarophytes and brown seaweeds, respectively.

The Philippines is the world's largest producer of carrageenophytes. From virtually zero production in the 1960s, the country has provided up to 80% of global supply of carrageenan through aquaculture in the 1990s. The annual production for farmed seaweeds, mainly carrageenophytes, in the Philippines for the period 1990-1999 is given in Table 1.

Table 1: *Cultured Seaweed Production in the Philippines (1990-1999)*

Year	Production* (MT)
1990	291,176
1991	283,783
1992	349,505
1993	400,920
1994	481,002
1995	557,879
1996	630,947
1997	626,482
1998	209,595
1999	620,620

* Wet Weight

HISTORY AND DEVELOPMENT

Prior to the development of the carrageenophyte production industry in the Philippines, the only sources of carrageenan were the red seaweeds *Chondrus* and *Gigartina* from the Atlantic coasts of Canada and Europe. In the 1960s, wild stocks of the red seaweeds, *Kappaphycus alvarezii* (Syn. *Eucheuma cottonii*) and *Eucheuma denticulatum* (Syn. *E. spinosum*) were identified as alternative source of carrageenan in the Philippines. Initial culture trials conducted by the late Dr Maxwell Doty in Siasi, Jolo in 1972 led to the birth of the carrageenophyte farming industry in the country.

The industry made its first export of 500 metric tonnes of cultured carrageenophytes in 1973. In 1979, the Philippines became the world's leading supplier of Philippine Natural Grade (PNG) carrageenan.

In 1999, the Philippines exported 8,184 metric tonnes of carrageenan with a value of US $ 41.54 million (Table 2). Indonesia (22,000 MT), Chile (14,000 MT), Zanzibar (4000 MT) and Canada (3,500 MT) are the other major producers of carrageenan.

Table 2: *Carrageenan Exports in the Philippines (1999)*

Country	Quantity (MT)	FOB Value (US $)
Denmark	644	6,746
France	1,177	6,190
United Kingdom	1,391	5,804
Others	4,972	22,803
Total	**8,184**	**41,543**

PRODUCTION OF CARRAGEENOPHYTES

In 1999, seaweed production dominated the aquaculture output of the Philippines with 65.4% contribution (Table 3). There are 8,000-10,000 hectares of seaweed farms mainly in the shallow coastal waters of Tawi-Tawi, Jolo, Zambonga, Palawan and Bohol (Shown in Map & Table 4) providing income and livelihood to more than 100,000 families living in such coastal areas.

Table 3: *Production of Major Aquacultural Species in the Philippines (1999)*

Species	Quantity (MT)	Percentage
Seaweeds	620,620	65.4
Milkfish	170,677	18.0
Tilapia	75,437	7.9
Shrimps	35,898	3.8
Mussels	15,498	1.6
Oysters	13,698	1.4
Others	18,031	1.9
Total	949,859	100.0

1. Site Selection

The suitable sites for farming of carrageenophytes are marine inter-tidal and sub-tidal zones with rocky or sandy bottoms. There should be a minimum depth of 30 cm at the lowest tide. Water movement in the culture area is essential. Current speeds of 20-40 m per minute are desirable.

Map of the Philippines showing carrageenophytes farming areas

Table 4: *Location of Carrageenophytes Farming Areas in the Philippines: Total Area and Production (1999)*

Province	Hectares	Production (MT)*
Tawi-Tawi	2,688	33,600
Jolo	1,920	24,000
Zamboanga	1,536	19,200
Palawan	998	12,480
Bohol	407	4,340
Others	630	4,380
Total	**8,179**	**98,000**

* Dry Weight

For new sites, test planting is recommended. This is done by planting seaweed cuttings at several places in the site. If the seaweed cuttings grow two to three times their original weight after one month, the site is suitable.

Sub-tidal coastal areas with rocky-sandy bottom such as this are used for seaweed farming

2. Source of Planting Material

The planting material is obtained from available sources. The choice of species/variety of carrageenophyte to plant depends on the availability, quality of carrageenan, season and location. The *Kappaphycus* is the most extensively grown carrageenophyte in the Philippines followed by the *Eucheuma*. The former yields kappa carrageenan (hard-gelling) and the latter, iota carrageenan (non-gelling).

Kappaphycus alvarezii , known as cottonii of commerce, is the most common and fast-growing farmed species of carrageenophyte in the Philippines, Indonesia, Malaysia, Tanzania and Micronesia. It grows well in sites with very strong water current at low temperature. The Sacol strain performs well in shallow reef flats on sandy or grassy bottom and can grow round the year.

Eucheuma denticulatum, the spinosum of commerce, thrives during the warm months of the year. Demand for the species, however, is not as high as that for *Kappaphycus.*

3. Methods of Farming

The common methods of growing carrageenophytes in the Philippines are the monoline-stake method in shallow water (0.5-3m) and the monoline-raft method in deepwater (>3m). Figures 1 & 2 illustrate the two methods.

In the first method, the farm site is prepared by clearing the area of seagrasses, seaweeds, large stones and predators like sea urchins. Wooden stakes measuring 1.2 m in length and 4 cm in diameter are then driven into the bottom with a sledge hammer at a distance of 5-10 m between stakes and 0.5 m between rows. The nylon monolines (200-lb test–evelon cord) are then securely tied to the stakes at a distance of 0.3-0.5 m from the bottom. The planting material or seaweed cuttings (100-300 g) are tied to the monolines at 15-25 cm intervals with 25 cm long soft plastic straw. Figures 3-5 illustrate the

CULTIVARS OF CARRAGEENOPHYTES AND THEIR COLOURS

K. alvarezii
Green

K. alvarezii
Dark green to brown

K. alvarezii
Dark brown-green

K. alvarezii
Brown

K. alvarezii : Dark to
greyish brown green

K. alvarezii
Brown, "eel type"

K. alvarezii : Brown
giant Bohol

K. alvarezii
Dark red to reddish brown

Kappaphycus sp.: Sacol
var.-Tawi-Tawi green

Kappaphycus sp.: Sacol
var.-Bohol, green

Eucheuma denticulatum
Green

Eucheuma denticulatum
Brown

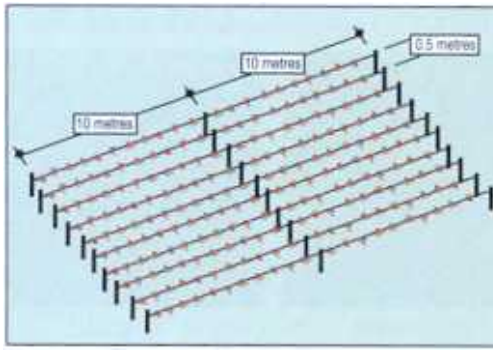

Figure 1: Monoline-stake method of farming carrageenophytes

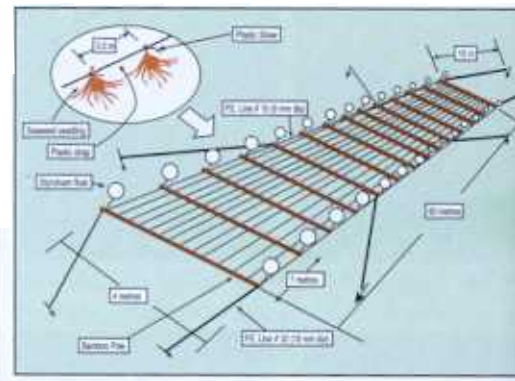

Figure 2: Monoline-raft method of farming carrageenophytes

Seaweed farms using the raft system of culture

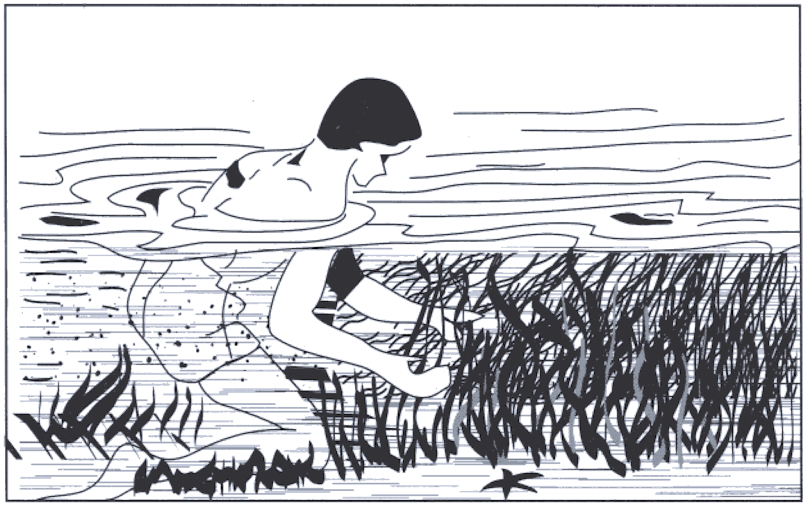

Figure 3: Clearing of sea-grasses in a new seaweed farming site

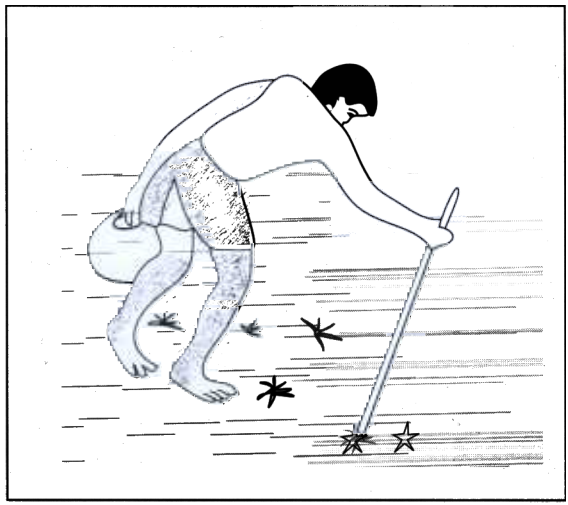

Figure 4: Removal of predatory animals like sea urchins in a seaweed farming site

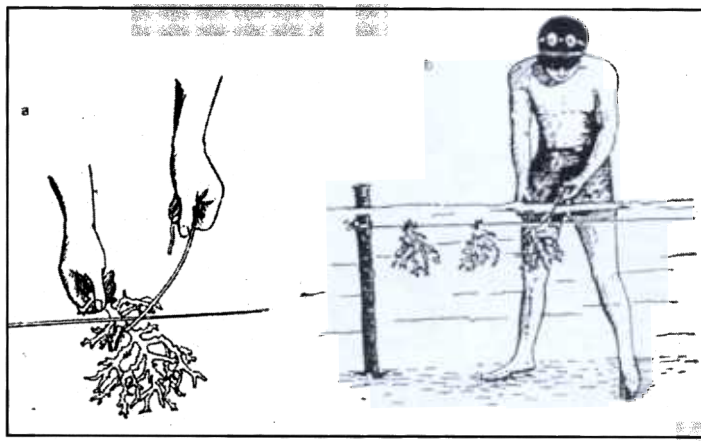

Figure 5: Tying of the "seedling" to the monoline

steps involved in this farming method. Farm areas range in size from 0.1 to 1 ha.

In the monoline-raft method, the monolines are arranged as in the monoline-stake method with the exception that instead of stakes, bamboo beams are used. With the bamboo as float, the structure is secured to the bottom with stakes using evelon cord (*Figures 6 & 7*).

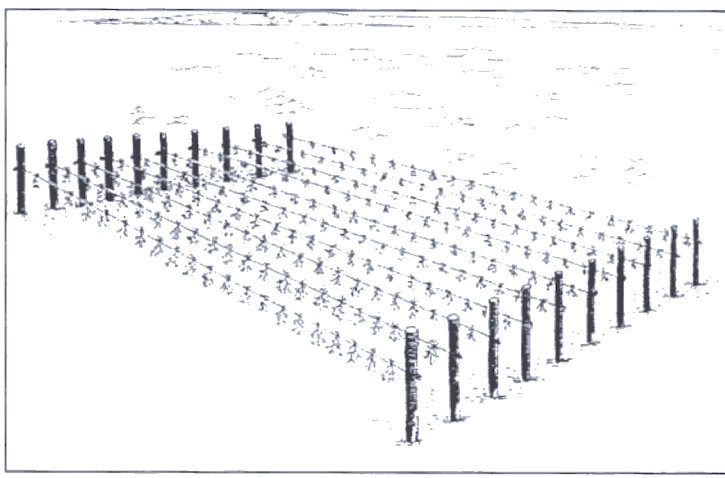

Figure 6: Monoline-stake method of farming carrageenophytes

Seaweed seedlings" being prepared for planting

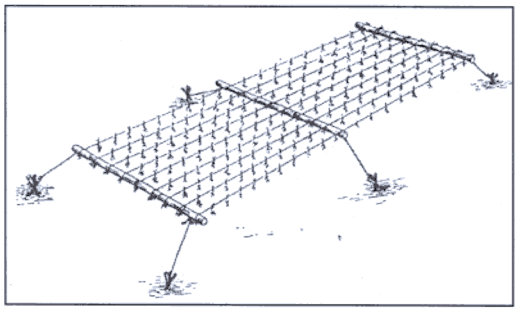

Figure Monoline-raft method of farming carrageenophytes

Seaweed cuttings tied monolines raft system

4. Maintenance of Seaweed Farm

Proper maintenance of the cultured plants is essential for good harvests. The following steps should be observed:

a. Keep the plants clean by weeding out other plants that compete for nutrients and sunlight.

b. Remove grazers such as sea urchins and rabbit fishes.

c. Replace lost and unhealthy plants.

d. Tighten loose monolines.

5. Harvesting of Seaweeds

The cultured plants are harvested when they reach a weight of one kilogram or more after 2-3 months of growth depending on the site and the season. In harvesting, the most common practice is to gather all the plants. The planting material for the next crop is selected from the "best looking" harvested plants and temporarily stored in a seedbin.

The harvested plants are placed on small motorized boats or bamboo rafts and transported to holding areas for drying and storage.

The yield from a one hectare seaweed farm can be as much as 48 metric tonnes (wet weight) within two months. With five crops a year, a farmer can derive a net income of P60,000 – P80,000 (US$1 = P44.8). The cost of operation and maintenance represents 40-60% of total income.

Unloading of harvested seaweeds from a motorized boat

POST-HARVEST HANDLING AND PROCESSING

Fresh seaweeds are sun-dried for 2-3 days on elevated platforms to a moisture content of 35-38% and placed in gummy sacks for storage. While being dried, the seaweeds should be protected from rain and dew by covering them. Contamination of the dried seaweed with sand, dirt and other foreign materials is avoided. Depending on moisture content (35-38%), it takes five to seven kilograms of fresh seaweeds to produce one kilogram of dried seaweeds.

Drying platform for seaweeds (note: sheets for protection against rain)

Dried seaweeds are processed into PNG carrageenan, semi-refined carrageenan and refined carrageenan in commercial plants. The flow chart for the production of carrageenan with different extraction methods is shown in Figure 8.

Loading of dried seaweeds in sacks

A commercial seaweed processing plant in Mandaue City, Cebu, Philippines

Semi-refined carrageenan being packaged at a commercial firm in Cebu, Philippines

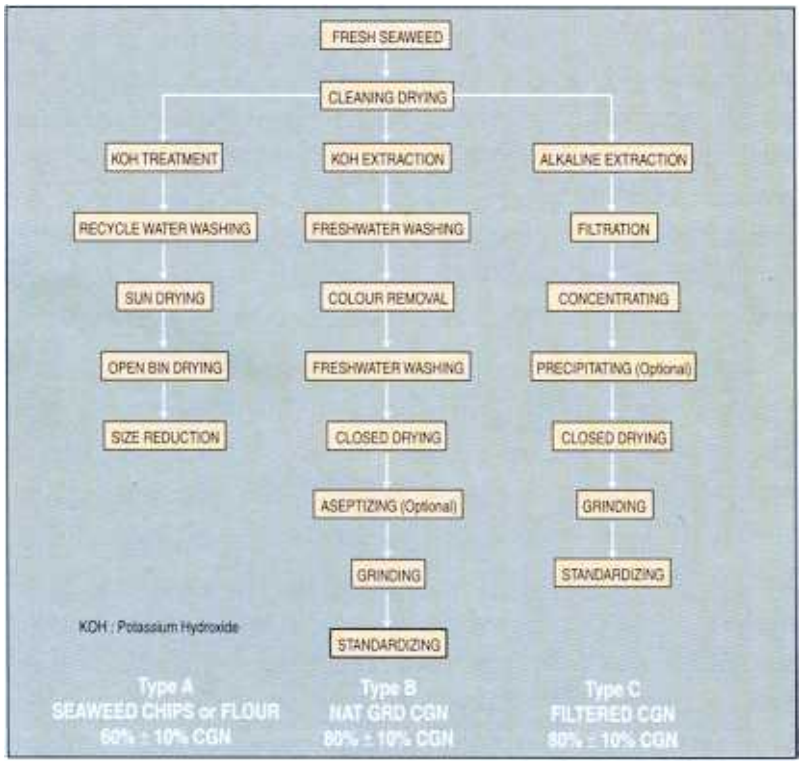

Figure 8: Carrageenan Extraction Process

TRANSFER OF TECHNOLOGY AND INDUSTRY PROMOTION

The technologies for the farming of carrageenophytes have been widely disseminated to and adopted by coastal fisherfolk in the country. The Philippine Bureau of Fisheries and Aquatic Resources (BFAR) supported the culture trials in the 1970s and conducted training programmes for seaweed farmers.

Training of extension workers has been regularly conducted by the BFAR in the seaweed farming regions of the country. Fisherfolk on the other hand, are trained by the extensionists on the culture methods and are assisted in the setting up of their farms with credit assistance from the government and private lending institutions. More than 10,000 fisherfolk and members of fishermen's associations have benefited from such extension activities with assistance from non-governmental organizations and private companies over the years.

A seaweed industry association has been organized in the Philippines to support the development of seaweed farming and in partnership with the government, provide technical and financial assistance to farmers.

For providing an alternative or supplemental means of livelihood for fishermen and their families particularly in coastal areas with overexploited fisheries resources, the government has identified suitable culture sites and promoted carrageenophyte growing industry. Farming permits are issued by Local Government Units (municipalities) to growers. Culture areas of up to one hectare are allowed for individuals and 30 hectares for cooperatives and corporations.

Through the joint efforts of the government, the academic institutions and private sector, the growth of seaweed farming in the Philippines has been phenomenal. Thus, it is today the fastest growing aquaculture industry in the country.

Carrageenophytes Farming – a growing industry in the Philippines

SECRETS OF SUCCESS

The key factors for the success of carrageenophytes farming in the Philippines are the strong export demand, R&D support of the government and academic institutions, and the active role of the private sector.

The increasing need for carrageenan in the global market has spurred the growth of carrageenophytes farming. Government agencies as well as state colleges and universities have extended technical and extension services to seaweed farmers. Private companies, on the other hand, have also assisted farmers with technical, credit and marketing support.

The acceptance of PNG carrageenan as a food additive in the United States and Europe has paved the way for further expansion of the carrageenophytes market.

The diverse applications and uses of carrageenan are given in Table 5.

Table 5: *Applications and Uses of Carrageenan*

APPLICATIONS	USES
FOOD	
• Beer/Wine/Vinegar	– Accelerates and improves clarity
• Chocolate Milk Drink	– Stabilizes and improves viscosity
• Ice Cream	– Prevents formation of ice crystals and imparts excellent mouth feel
• Flans/Dessert Gel	– Enhances flavour release and imparts excellent mouth feel
• Sauces and Dressings	– Thickens and improves viscosity
PROCESSED MEAT	
• Beef patty	– Substitutes fat, retains moisture and increases yield
• Luncheon Meat	– Prevents fat separation and serves as a meat extender
• Poultry and Ham	– Controls dehydration of frozen poultry, enhances juiciness and increases yield
NON-FOOD	
• Pet Food	– Moist, solid pet food binder
• Canned Meat and Fish	– Gelling and stabilizing agent
• Toothpaste	– Stabilizer
• Air Freshner	– Gelling Agent

PROSPECTS FOR REGIONAL COOPERATION

With the attractive export market, other countries in the Asia-Pacific Region like China, Indonesia, Fiji and Micronesia have taken interest in the farming of carrageenophytes. The identification of suitable culture areas and the provision of adequate development support in such countries will augur the increasing carrageenophyte production in the region.

Through the auspices of the Food and Agriculture Organization of the UN under its Technical Cooperation Among Developing Countries (TCDC) programme, the Philippines has shared its experience and technologies for carrageenophyte farming with its neighbours particularly in Southeast Asia (Indonesia and Malaysia) and the Pacific (Fiji and Micronesia). The First Asia-Pacific Regional Workshop on the Production and Utilization of Seaweeds was held in Cebu City, Philippines on August 27-31, 1990. The workshop was sponsored by the United Nations Development Programme/Food and Agriculture Organization Regional Seafarming Development and Demonstration Project and hosted by the Seaweed Industry Association of the Philippines, the Bureau of Fisheries and Aquatic Resources and the University of the Philippines' Marine Science Institute. Participants from Bangladesh, China, Indonesia, Japan, Republic of Korea, Malaysia, Myanmar, Thailand and the Philippines took part in the workshop.

FUTURE STRATEGIES FOR CARRAGEENOPHYTE RESEARCH

To ensure the sustainability and quality production of its carrageenophyte farming industry, the Philippine Government through the National Economic Development Authority and Department of Science and Technology (DOST) through the Philippine Council for Aquatic and Marine Research and Development (PCAMRD) has supported research on the development of improved strains of *Kappaphycus, Eucheuma* and other important seaweed species.

Research on seaweed seedstock improvement is ongoing with support from the DOST and the United Nations Development Programme. A facility for the culture of small branches (micro-propagules of *Kappaphycus* and *Eucheuma* has been established at the University of the Philippines' Marine Science Institute and at a private company in Cebu.

The micropropagule culture of 12 *Kappaphycus* and three *Eucheuma* strains collected from Bohol, Tawi-Tawi and Batangas is being done. DNA fingerprinting (RAPD) of fourteen *Kappaphycus* and *Eucheuma* cultivars has been generated for the first time in the gene-bank. Such fingerprints will serve as a basis for genetic classification and identification of the cultivars for biodiversity conservation and protection from biopiracy.

Experiments on protoplast infusion for somatic hybridization of seaweeds are also underway at the genebank. Initial results on the isolation and culture of carrageenase-producing bacteria have shown promise. The enzyme carrageenase is used to digest the cell wall of red seaweeds which are mainly made up of carrageenan.

Cultivars of Kappaphycus alvarezii

Facility for DNA fingerprinting of carrageenophyte cultivars at the Marine Science Institute of the University of the Philippines

The selection of seaweed strains is based on key characteristics such as growth, resistance to diseases and carrageenan yield.

In field experiments, the *Kappaphycus* Sacol variety had the best growth and resistance to "ice-ice" (a disease related to adverse environmental conditions such as high temperature and poor water circulation) in Batangas and Bohol. In Tawi-Tawi, the *Eucheuma* cultivars showed faster growth compared to the *Kappaphycus* cultivars. In terms of carrageenan yield, the *Kappaphycus* Sacol-Bohol variety

Seaweed germplasm bank of the Marine Science Institute, University of the Philippines

gave the highest yield in Batangas followed by the local *K. alvarezii* cultivars.

Mixed cropping of different *Kappaphycus* and *Eucheuma* strains is presently being practised. With information on the seasonality of the strains/cultivars, recommendations for specific periods for seedstock management and cropping have been given to the farmers. For instance, for the Sacol strain of *K. alvarezii*, seed production and cropping are done in September to October and December to August, respectively, in Bohol. The Sacol strain was found to have grown as much as 330% more in comparison to the local cultivar in Calatagan, Batangas.

The use of fast-growing, disease-resistant and high carrageenan-yielding cultivars is expected to improve production and market impact of carrageenophyte farms in the Philippines.

A plan to establish a nationwide carrageenophyte seedstock bank to supply farmers with the improved cultivars is being considered. Three seedstock banks in Batangas, Bohol and Zamboanga have already been established.

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